A Space Dust Experiment (Spadus) for Measurement of the Distribution of Man-Made and Natural Dust in the Near-Earth Space FOR Flight on the P91-1 Advanced Research and Global Observation Satellite (*ARGOS*)

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Award # N00014-91-J-1716

GOALS

1. To develop instrumentation to measure for the first time individual dust particle velocities, trajectories, and spatial distributions with sufficient accuracy to identify their parent bodies from the orbital characteristics of the dust in near-Earth space;

2. To accurately measure particle mass distributions and dust fluxes, with immunity to possible intense backgrounds from radiation belts and/or intense magnetic fields;

3. To develop design and implementation strategies for large-area sensors and sensor arrays to maximize data collection under condition of low particle flux for future investigations of debris dust and of natural dust streams, and;

4. To develop instrumentation providing very high time resolution (15 ms) charge particle (electrons, protons, and heavier nuclei) energy distribution measurements within radiation belts.

OBJECTIVES

In furtherance of these objectives—with support from ONR Grant No. N00014-91-J-1716, NASA Grant NAGW-3078, in-house funding from the Naval Research Laboratory, and funding from the Lockheed Space Sciences Laboratory—we have developed the SPADUS experiment. This instrument is to be launched into a Sun-synchronous orbit on the *ARGOS P91-1* spacecraft in December, 1998. The prime scientific and engineering objectives of SPADUS are:

1. <u>Dust Particles</u>

   a) To provide definitive measurements of the mass, flux, velocity and arrival directions of individual particles in near-Earth space, both for man-made particles (orbital debris) and for particles of natural origin. These measurements will be carried out over a particle size range in which there are little quantitative data available (particle diameter range ~ 2 to 200 microns);

Report Documentation Page

Form Approved
OMB No. 0704-0188

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1. REPORT DATE **1998**	2. REPORT TYPE	3. DATES COVERED **00-00-1998 to 00-00-1998**

4. TITLE AND SUBTITLE **A Space Dust Experiment (Spadus) for Measurement of the Distribution of Man-Made and Natural Dust in the Near-Earth Space FOR Flight on the P91-1 Advanced Research and Global Observation Satellite (ARGOS)**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of Chicago, Enrico Fermi Institute,Laboratory for Astrophysics and Space Research,933 E. 56th Street,Chicago,IL,60637**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM002252.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**5**	

b) To provide a survey map based on the above three-dimensional measurements that will establish a baseline of the present near-Earth dust distribution and that will provide crucial data for evaluating current models of the debris hazards in near-Earth space;

c) To determine the trajectory for each incident cosmic dust particle and thus to determine its likely origin as either man-made orbital debris (occupying primarily bound, near-circular orbits) or from natural sources — e.g., comets, asteroids, zodiacal cloud (occupying primarily unbound hyperbolic orbits);

d) To search for transient dust flux increases from interplanetary dust stream encounters;

e) To obtain direct data on orbital and size distribution for small debris particles;

f) To characterize the spatial and temporal characteristics of orbital debris (debris streams);

g) To obtain data that will permit determination of hazards to critical surfaces exposed to near-Earth space particulates in military and civil space programs, and;

h) To improve our understanding of the dynamical properties and evolution of small orbital debris particles.

2. Energetic Charged Particles (Electrons, Protons and Heavier Nuclei):

a) To obtain fast spectral snapshots of midlatitude Lightning-induced Electron Precipitation (LEP) events to better understand what is considered a major loss mechanism of the Earth's radiation belts. The flux from an individual event can be of the order of 10^5 cm^{-2} s^{-1} sr^{-1} between 20 to 100 keV. The structure of these events can be studied for the first time at a time resolution of 15 ms;

b) To provide the only monitoring of the charged particle environment on *ARGOS* for understanding backgrounds, enhanced solar flare particle fluxes, and anomalies, and;

c) To obtain coordinated measurements with other *ARGOS* experiments. This is an opportunity to study the details of the aurora with the NRL state-of-the-art UV imagers and uniquely measure the size of LEP events with the high-sensitivity X-ray imager (USA experiment).

The SPADUS flight instrument is shown in **Figure 1** and consists of: (a) a dust trajectory system consisting of two identical dust sensor arrays (D1 plane and D2 plane); (b) a digital electronics box containing the Ancillary Diagnostic Sensor (ADS) charged-particle sensor system, and; (c) the analog electronics box.

Following the launch of *ARGOS P91-1*, the *SPADUS* instrumentation will be the first to provide accurate information concerning particle trajectories and temporal variations in the microparticle environment in low-Earth orbit, a region of great practical important for satellites and human activity in space.

APPROACH

The experimental approach used in the *SPADUS* experiment to achieve these objectives uses the polyvinylidene fluoride (PVDF) dust sensor developed at the University of Chicago under earlier NASA and ONR support. PVDF detectors have been incorporated in the DUCMA dust experiment on the *VEGA* missions to Comet Halley, in the (classified) *ERIS* mission, and are included in the Cosmic Dust Analyzer experiment on the *Cassini* mission to Saturn and on the Dust Flux Monitor Instrument (DFMI) to be flown on the *Stardust* mission to Comet WILD-2.

ACCOMPLISHMENTS

During FY98 the following tasks were accomplished:

1. The set of sixteen (16) re-designed D1 sensors successfully passed spacecraft test acoustic levels and *SPADUS* was reassembled for follow-on spacecraft testing.

2. New silicon sensors were installed in the *SPADUS* ADS telescope to replace the sensors which had degraded with time.

3. The results of all *SPADUS* data accumulated during spacecraft testing to-date show normal operation for the *SPADUS* instrument.

RELATIONSHIP TO OTHER PROGRAMS AND PROJECTS

The ONR *SPADUS* work is strongly related to other dust and debris projects within NASA. Specifically:

1. The University of Chicago High Rate Detector (HRD) instrument for the NASA/ESA *Cassini* mission to Saturn was developed by the same scientific and technical staff responsible for *SPADUS* development (funded through JPL).

2. The *SPADUS* concept serves as the basis for the University of Chicago Dust Flux Monitor Instrument (DFMI) to be launched on NASA's *Stardust* mission.

3. The study of the small particle debris environment in near-Earth orbit has been identified as a high priority by NASA, ESA and other governmental agencies concerned with space activities, as indicated by the following documents:

    - European Space Agency, "Space Debris," SP-1109, Paris, 1988

    - R.C. Reynolds and A.E. Potter, Jr., "Orbital Debris Research at NASA Johnson Space Center". Technical Memorandum 102155, National Aeronautics and Space Administration, Houston, Texas, 1989

- U.S. National Security Council, “Report on Orbital Debris,” Washington, D.C., 1989

- U.S. Congress, General Accounting Office, “Space Program: Space Debris a Potential Threat to Space Station and Shuttle,” Washington, D.C., 1990

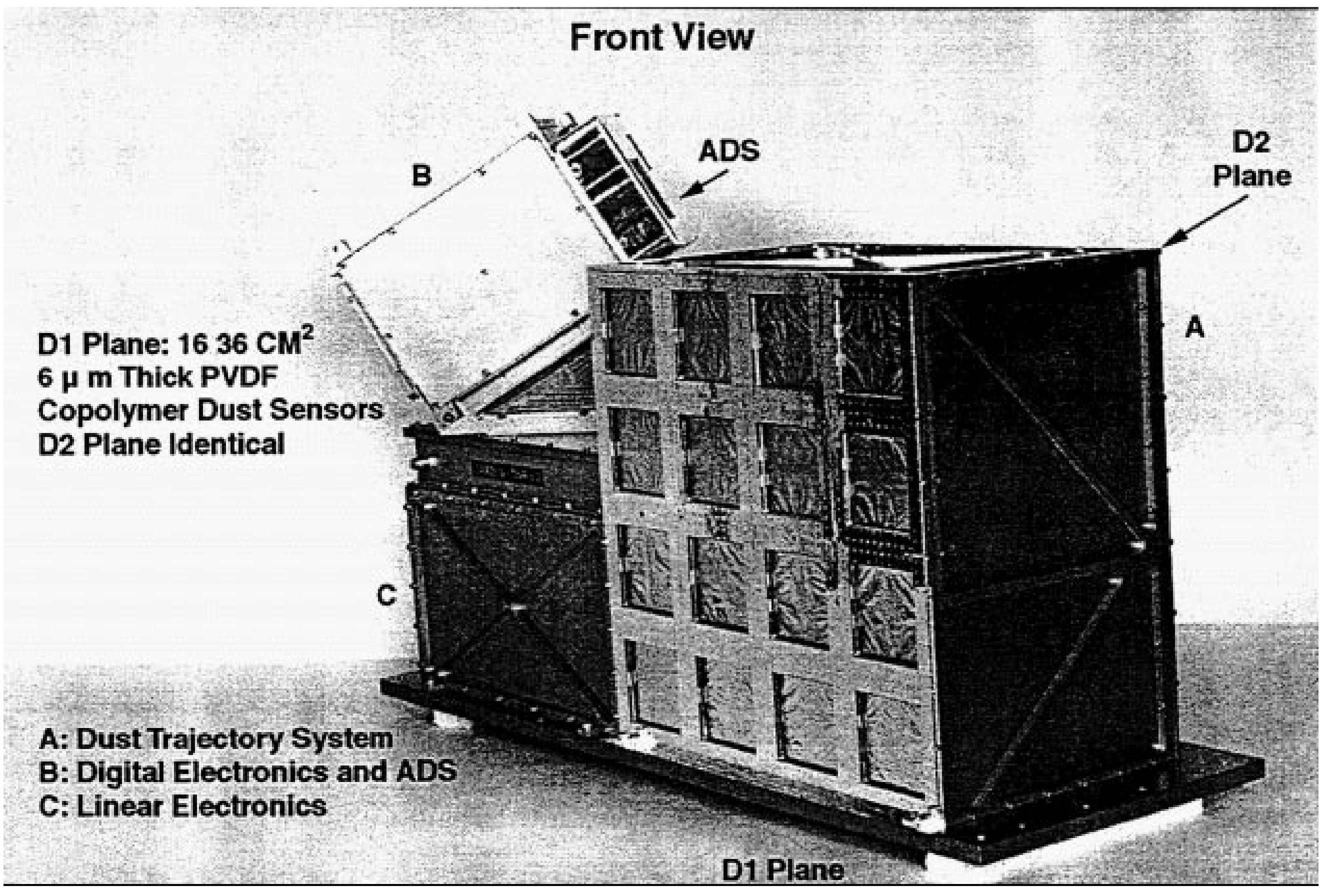
- U.S. Congress, Office of Technology Assessment, “Orbiting Debris: A Space Environmental Problem — Background Paper,” OTA-BP-ISC-72, Washington, D.C.: U.S. Government Printing Office, 1990

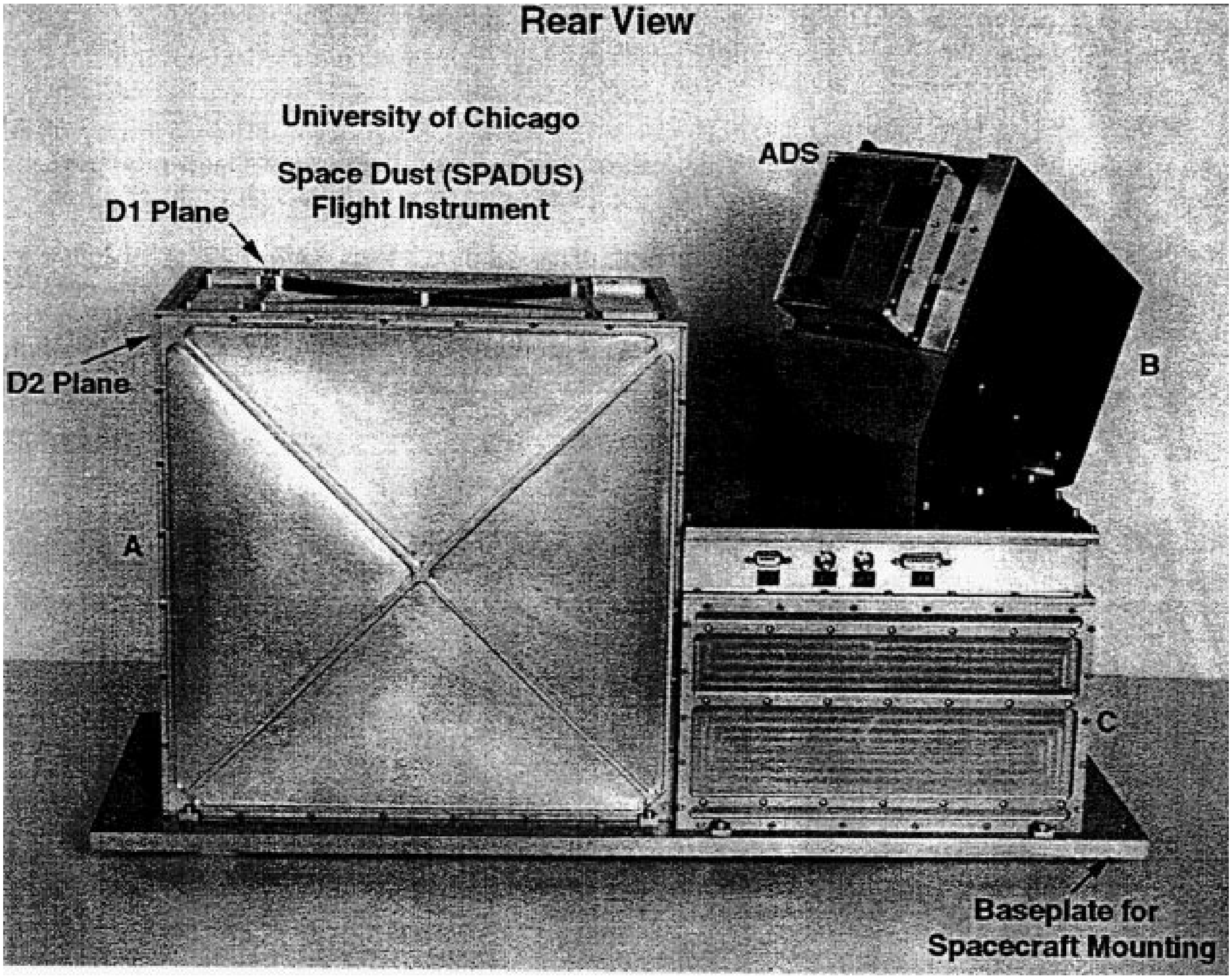
- “Preservation of Near-Earth Space for Future Generations.” J.A. Simpson, ed., Cambridge University Press, 1994.

PUBLICATIONS FROM ONR SPONSORED WORK: FY98

Tuzzolino, A.J., “The High Rate Detector Component of the COSMIC DUST ANALYZER (CDA)”, to be published in *Space Science Reviews*, 1999.

Tuzzolino, A.J., McKibben, R.B. and Simpson, J.A., “The DUST FLUX MONITOR INSTRUMENT (DFMI) for the *Stardust* Mission”, to be published in the *Journal of Geophysical Research*, 1999.




Rear View
University of Chicago
Space Dust (SPADUS)
Flight Instrument
ADS
D1 Plane
D2 Plane
B
A
C
Baseplate for
Spacecraft Mounting